

CLAIMS

We claim:

1. A method of forming a substantially planar surface of an optical waveguide device, comprising the steps:

forming at least one waveguide core portion within at least one cladding portion; the waveguide core portion having an upper surface; the cladding portion having a higher portion over at least the waveguide core portion and a lower portion;

forming a patterned sacrificial portion over the lower cladding portion and a portion of the higher cladding portion, leaving a second portion of the higher cladding portion exposed;

removing at least a portion of the higher cladding exposed portion by a selective removal process selective to the patterned sacrificial portion leaving a remnant of the higher cladding exposed portion;

planarizing:

the remnant of the higher cladding exposed portion over the waveguide core portion; and
the lower cladding portion;

to a predetermined thickness over the upper surface of the waveguide core portion and the upper surface of the cladding portion coplanar with the smooth upper surface of the waveguide core portion; to form the substantially planar surface of an optical waveguide device.

2. The method of claim 1, wherein the predetermined thickness is between about 0 and 200 nm.

3. The method of claim 1, wherein the cladding portion has a first index of refraction; the waveguide core portion has a second index of refraction; and the waveguide core portion second index of refraction is greater than the cladding portion first index of refraction.

4. The method of claim 1, wherein the planarization is a chemical mechanical polishing process.

5. The method of claim 1, wherein the waveguide core portion comprises at least one waveguide core embedding within at least another waveguide core.

6. The method of claim 1, wherein the patterned sacrificial portion is comprised of: photoresist; or

photoresist stacked upon a film comprised of: silicon nitride, silicon oxynitride organic silicate glass, diamond like carbon, silicon dioxide, polyimide, PMMA, tantalum, tungsten or molybdenum.

7. The method of claim 1, wherein the cladding portion is comprised of silicon nitride, organic silicate glass, silicon dioxide, polyimide or PMMA.
8. The method of claim 1, wherein the selective removal process selective to the patterned sacrificial portion is a dry and/or wet etching process.
9. The method of claim 1, wherein the patterned sacrificial portion is removed before the planarization.
10. The method of claim 1, wherein the sacrificial portion is photoresist and the patterned sacrificial photoresist portion is removed before the planarization by a stripping process.
11. The method of claim 1, wherein the waveguide core portion is formed using a first mask; and the patterned sacrificial portion is patterned from a sacrificial layer using a second mask that is the reverse of the first mask.

12. The method of claim 1, wherein the planarization also removes the patterned sacrificial portion protruding remnant.
13. The method of claim 1, wherein waveguide core portion is formed using a first mask; and not all the sacrificial portion area is needed to be patterned using a second mask that is the reverse of the first mask.
14. The method of claim 1, wherein the patterned sacrificial portion is also removed during the planarization.
15. The method of claim 1, wherein the planarization includes a fine planarization process.
16. The method of claim 1, wherein the planarization of the remnant of the higher cladding exposed portion over the waveguide core portion and the lower cladding portion does not expose the upper surface of the waveguide core portion.
17. A method of forming a substantially planar surface of an optical waveguide device, comprising the steps:
forming at least one waveguide core portion within at least one cladding portion over a wafer; the waveguide core portion having an upper surface; the

cladding portion having a higher portion over at least the waveguide core portion and a lower portion;

forming a sacrificial portion, having a different chemical behavior from the cladding portion, over the wafer;

removing the sacrificial portion from over the higher cladding portion by a first planarization process, leaving exposed:

the higher cladding portion;

the patterned sacrificial portion over the lower cladding portion;

and

a portion of the cladding portion adjacent the patterned sacrificial

portion over the lower cladding portion;

removing the higher cladding portion and a portion of the sacrificial portion by a second, selective, planarization process, leaving the patterned sacrificial portion over the lower cladding portion exposed; then

non-selectively planarizing:

the patterned sacrificial portion over the lower cladding portion; and

the lower cladding portion;

to:

a predetermined thickness over the upper surface of the waveguide core portion and the upper surface of the cladding portion coplanar with the smooth upper surface of the waveguide core portion;

to form the substantially planar surface of an optical waveguide device.

18. The method of claim 17, wherein the cladding portion has a first index of refraction; the waveguide core portion has a second index of refraction; and the waveguide core portion second index of refraction is greater than the cladding portion first index of refraction.
19. The method of claim 17, wherein the removal of the sacrificial portion from over the higher cladding is a chemical mechanical polishing process using a slurry active to the sacrificial portion.
20. The method of claim 17, wherein the waveguide core portion comprises at least one waveguide core embedding within at least another waveguide core.
21. The method of claim 17, wherein the second, selective, planarization process is a chemical mechanical polishing process.
22. The method of claim 17, wherein the patterned sacrificial portion is SiN, organo-silicate glass (OSG), diamond-like carbon (DLC) or a refractory metal.

23. The method of claim 17, wherein the predetermined thickness is from about 0 to 200 nm.

24. The method of claim 17, wherein the second, selective, planarization process is a chemical mechanical polishing process using a slurry with a removal rate of high cladding dielectric and greater than the removal rate of sacrificial material.

25. The method of claim 17, wherein the second, selective, planarization process is a chemical mechanical polishing process using a slurry active to the sacrificial portion and the lower cladding portion.

26. The method of claim 17, wherein the first and second planarization processes are each a fine planarization process.

27. The method of claim 17, wherein the first planarization process is an etching process with an etch selectively to the cladding portion greater than an etch selectively to the sacrificial portion.

28. A method for producing at least two waveguide core regions made from dissimilar materials using chemical mechanical polishing, wherein said core regions are integrated on a single substrate

29. The method of claim 28 wherein at least one waveguide core is embedded in at least other waveguide one other core.

30. A method for producing etch-damage free optical waveguide structures, comprising the following steps:

depositing etch buffer layer after waveguide formation;

etching of buffer layer except on the top of waveguide;

5 depositing a coupling dielectric;

optionally planarizing the coupling dielectric surface;

forming the upper part of a coupling zone by patterning; and

etching with the buffer layer being etched also but not fully to protect the

waveguide; and

10 depositing a cladding dielectric.

31. The method of claim 30 wherein cladding dielectric is selected from the group consisting of silicon dioxide, silicon nitride, organic silicate glass, Polyimide and PMMA.

32. The method of claim 30 wherein buffer layer is same material as the cladding material or optically similar, where the difference of refractive index is less than 0.2.

33. A low loss waveguide device consisting of:

- a waveguide core;
- a buffer layer on top of said waveguide core; and
- a dielectric material surrounding said waveguide core;

wherein:

the top part of said buffer layer has a refractive index substantially close to the refractive index of said dielectric material surrounding said waveguide core; said buffer layer being deposited before etching of said waveguide core; and said waveguide device is fabricated on a substrate.

34. The low loss waveguide device of claim 33, wherein said dielectric material surrounding said waveguide core is:

a cladding region if there is a single waveguide core; and
a low index core if said waveguide core is embedding in said dielectric material.

35. The low loss waveguide device of claim 33, wherein said buffer layer has a refractive index equal to said dielectric material surrounding said waveguide core.

36. The low loss waveguide device of claim 33, wherein said buffer layer is used as at least a part of an etch mask for etching of said waveguide core.

37. The low loss waveguide device of claim 33, wherein said buffer layer is used as a sacrificial region to accommodate resist erosion.

38. The low loss waveguide device of claim 33, wherein said buffer layer is used to protect said waveguide core from photoresist strip and associated cleaning steps.

39. The low loss waveguide device of claim 33, wherein said buffer layer has a graded refractive index distribution.

40. The low loss waveguide device of claim 33, wherein said buffer layer is used to protect said waveguide core from one or more subsequent chemical mechanical polishing steps.

41. The low loss waveguide device of claim 33, wherein said waveguide core is integrated monolithically with at least one other waveguide core which is not co-planar with said low loss waveguide device.

42. The low loss waveguide device of claim 33, wherein said buffer layer has a refractive index substantially different from the refractive index of said waveguide core.

43. The low loss waveguide device of claim 42, wherein said buffer layer has a refractive index equal to the refractive index of said dielectric material surrounding said waveguide core.

44. The low loss waveguide device of claim 42, wherein said buffer layer is used as at least a part of an etch mask for said etching of said waveguide core.

45. The low loss waveguide device of claim 42, wherein said buffer layer is used as a sacrificial region to accommodate resist erosion.

46. The low loss waveguide device of claim 42, wherein said buffer layer is used to protect said waveguide core from a photoresist strip and associated cleaning steps.

47. The low loss waveguide device of claim 42, wherein said buffer layer has a graded index distribution.

48. The low loss waveguide device of claim 42, wherein said buffer layer is used to protect said waveguide core from one or more subsequent chemical mechanical polishing steps.

49. The low loss waveguide device of claim 42, wherein said said buffer layer has a refractive index substantially different from the refractive index of said waveguide core.

50. The low loss waveguide device of claim 33, wherein said waveguide core is integrated monolithically with at least one other waveguide core which is of a different material from said waveguide core.

51. The low loss waveguide device of claim 50, wherein said buffer layer has refractive index equal to a refractive index of: at least one other waveguide core; and of said dielectric region surrounding said waveguide core.

52. The low loss waveguide device of claim 50, wherein said buffer layer is used as at least a part of an etch mask for etching of said waveguide core.

53. The low loss waveguide device of claim 50, wherein said buffer layer is used as a sacrificial region to accommodate resist erosion.

54. The low loss waveguide device of claim 50, wherein said buffer layer is used to protect said waveguide core from a photoresist strip and associated cleaning steps.
55. The low loss waveguide device of claim 50, wherein said buffer layer has a graded index distribution.
56. The low loss waveguide device of claim 50, wherein said buffer layer is used to protect said waveguide core from one or more subsequent chemical mechanical polishing steps.
57. The low loss waveguide device of claim 50, wherein said said buffer layer has a refractive index substantially different from the refractive index of said waveguide core.